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SECOND PROGRESS REPORT ON THE BIOLOGY AND CONTROL OF

CYLINDROCOPTURUS EATONI BUCHANAN

By

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SECOND PROGRESS REPORT ON THE BIOLOGY AND CONTROL OF
CYLINDROCCOPTURUS EATONI BUCHANAN

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SECOND PROGRESS REPORT ON THE BIOLOGY AND CONTROL OF CYLINDROCOPTURUS EATONI BUCHANAN*

INTRODUCTION

DURING THE SPRING OF 1940, STUDIES INITIATED IN 1939 ON THE WEEVIL CYLINDROCOPTURUS EATONI BUCH. (PREVIOUSLY REPORTED UPON UNDER THE NAME CYLINDROCOPTURUS LONGULUS LEG.) WERE CONTINUED. MAJOR EMPHASIS WAS PLACED THIS SEASON ON THE TESTING OF CONTROL MEASURES. UNFORTUNATELY A CURTAILMENT OF FUNDS AND RESULTANT CHANGES IN PERSONNEL ASSIGNMENTS IN MID-SEASON BROUGHT ABOUT A SOMEWHAT PREMATURE SUSPENSION OF THIS WORK. IT WAS THEREFORE IMPOSSIBLE TO INVESTIGATE FULLY SEVERAL IMPORTANT PHASES OF THE PROBLEM AS HAD BEEN PREVIOUSLY PLANNED. HOWEVER, MUCH OF THE DATA ON THE LIFE HISTORY AND HABITS OF THE WEEVIL, ALREADY REPORTED, HAS BEEN CONFIRMED, AND SOME NEW DATA HAVE BEEN ADDED THAT ARE ESSENTIAL TO THE DEVELOPMENT OF ADEQUATE CONTROL MEASURES. THE PURPOSE OF THIS REPORT IS TO PRESENT A SUMMARY OF THIS INFORMATION, TOGETHER WITH A DESCRIPTION OF THE VARIOUS CONTROL MEASURES TESTED.

REVIEW OF PREVIOUS WORK

IN 1938 MEMBERS OF THE U.S. FOREST SERVICE REPORTED SERIOUS INSECT DAMAGE TO YOUNG PONDEROSA AND JEFFREY PINE TREES PLANTED IN THE BIG SPRINGS BRUSHFIELD, LASSEN NATIONAL FOREST. THE SEVERITY OF THE DAMAGE AND THE PAUCITY OF INFORMATION ON INSECTS THAT COULD CAUSE INJURY OF THIS SORT LED THE FOREST INSECT LABORATORY AT BERKELEY TO INITIATE STUDIES TO DETERMINE THE IDENTITY AND HABITS OF THE SPECIES INVOLVED IN THIS CASE. THE RESULTS OF THE INVESTIGATIONS HAVE ALREADY BEEN REPORTED UPON ELSEWHERE (EATON, 1940A), THEREFORE BUT A BRIEF REVIEW OF THE HIGHLIGHTS OF THE WORK IS NECESSARY HERE. IT WAS FOUND THAT:

1. A PREVIOUSLY UNDESCRIBED WEEVIL BELONGING TO THE GENUS CYLINDROCOPTURUS AND NATIVE TO AT LEAST THE LASSEN FOREST AREA WAS THE INSECT RESPONSIBLE FOR THE DAMAGE.
2. THIS WEEVIL OVERWINTERS IN THE LARVAL STAGE, PUPATES IN THE SPRING AND EMERGES DURING JUNE. THE ADULTS, WHICH ARE ACTIVE FLYERS, MATE AND THE FEMALES DEPOSIT THEIR EGGS IN THE STEM AND TWIGS OF SMALL TREES EARLY IN JULY. LARVAL DEVELOPMENT FROM THE EGG AND SUBSEQUENT FEEDING WITHIN THE CORTICAL AREA IS ACCOMPANIED BY THE DEATH OF THE TREE. BY THE TIME THE LATTER IS COMPLETELY BROWN, USUALLY IN LATE FALL, THE LARVAE ARE MATURE.

* THIS PROJECT WAS CONDUCTED BY THE DIVISION OF FOREST INSECT INVESTIGATIONS, BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE, IN COOPERATION WITH THE FOREST SERVICE. THE INVESTIGATIONS WERE PERFORMED BY THE WRITER UNDER SUPERVISION FROM THE BERKELEY STATION. FACILITIES FOR FIELD WORK WERE AVAILABLE AT THE HAT CREEK LABORATORY. ACKNOWLEDGEMENTS ARE DUE MR. S. F. POTTS OF THE FOREST INSECT LABORATORY AT NEW HAVEN, CONN., FOR SUGGESTIONS ON THE USE OF CONCENTRATED SPRAYS TESTED IN THIS STUDY.

3. INJURY TO THE HOST IS CAUSED BOTH BY THE FEEDING OF THE ADULT WEEVILS ON THE NEEDLES AND THE FEEDING OF THE LARVAE WITHIN THE CORTICAL AREA, BUT THE LATTER IS BY FAR THE MOST SERIOUS. THE ABILITY OF THE INSECT TO KILL HEALTHY NATIVE PINE REPRODUCTION WAS DEMONSTRATED THROUGH FORCED ATTACK STUDIES.

4. A BLUESTAIN FUNGUS, HORMISCIMUM GELATINOSUM HEDGC., WAS FOUND TO BE ASSOCIATED WITH THE WEEVIL (RUMBOLD, 1939) AND TESTS WERE MADE TO DETERMINE ITS PATHOGENICITY (ZENTMYER, 1939).

5. SURVEYS SHOWED THAT: (A) IN THE BIG SPRINGS BRUSHFIELD WEEVILS HAD KILLED BETWEEN 70 AND 90 PERCENT OF THE PINE IN THE SMALL AREAS PLANTED BETWEEN 1932 AND 1934, BUT THAT RELATIVELY MINOR DAMAGE HAD OCCURRED IN MORE RECENTLY PLANTED AREAS; (B) EVIDENCE OF WEEVIL ACTIVITY ON A VERY MINOR SCALE WAS PRESENT IN THE BURNEY SPRINGS PLANTATION; (C) WEEVIL-KILLED NATIVE REPRODUCTION WAS PRESENT SPORADICALLY THROUGHOUT THE BURNEY AREA.

6. FOR THE BIG SPRINGS PLANTINGS RECOMMENDATIONS WERE MADE THAT AN ATTEMPT TO CONTROL THE WEEVIL SHOULD BE TESTED BY ERADICATING INFESTED TREES BEFORE THE BROOD EMERGED IN THE SPRING.

TAXONOMY

ALTHOUGH PRELIMINARY DETERMINATIONS PLACED THE WEEVIL FROM BIG SPRINGS IN THE LONGULUS GROUP OF THE GENUS CYLINDROCOPTURUS, THE WIDE VARIABILITY IN HABITS AND HOSTS REPORTED FOR THIS GROUP PROVOKED SOME QUESTION EARLY IN THE STUDY ON THE LOGIC OF CONSIDERING ALL THE VARIETIES AS ONE ~~AS ONE~~ SPECIES. PRIOR TO THE RELEASE OF LAST YEAR'S REPORT, WORD HAD BEEN RECEIVED THAT THE BIG SPRINGS VARIETY WAS DISTINCT, BUT LACK OF SUFFICIENT INFORMATION ON THE CHARACTERS OF THE INSECT AS COMPARED WITH OTHER MEMBERS OF THE GROUP PREVENTED NAMING IT AT THAT TIME. RECENTLY, HOWEVER, MR. L. L. BUCHANAN, DIVISION OF INSECT IDENTIFICATION, PUBLISHED DESCRIPTIONS OF THREE NEW SPECIES (1940), OF WHICH ONE WAS THE WEEVIL UNDER CONSIDERATION IN THIS REPORT AND FOR WHICH HE HAS PROPOSED THE NAME CYLINDROCOPTURUS EATONI. HE STATES "... AFTER STUDYING THE TYPES, THE WRITER BELIEVES THAT CYLINDROCOPTURUS DISPERSUS CSY. (EASTERN PART OF THE UNITED STATES) AND C. OBSCURELLUS CSY. (COLORADO, NEW MEXICO, AND ARIZONA) NOW PLACED AS SYNONYMS OF C. LONGULUS LEC. (CALIFORNIA), ARE DISTINCT SPECIES." HE ALSO CONSIDERS AS NEW THE SPECIES INFESTING DOUGLAS FIR TWIGGS, REPORTED UPON BY FURNISS (1940), AND HAS APPLIED THE NAME C. FURNISSI TO THIS INSECT.

ADDITIONAL NOTES ON LIFE HISTORY

A RECHECK OF THE OBSERVATIONS MADE LAST SEASON INDICATES THAT THE LIFE HISTORY OF C. EATONI IS A RATHER PROSAIC AFFAIR, PERHAPS CHANGING SLIGHTLY FROM YEAR TO YEAR WITH VARIATIONS IN ENVIRONMENTAL FACTORS, BUT GENERALLY FOLLOWING THE SAME COURSE. SUPPLEMENTARY STUDIES WERE MADE THIS SPRING TO PROVIDE A MORE VALID BASIS FOR SOME OF THE STATEMENTS PREVIOUSLY MADE, BUT NO RADICAL DEPARTURES FROM THE LIFE CYCLE AS PREVIOUSLY DESCRIBED WERE NOTED.

LENGTH OF PUPAL STAGE

ORIGINAL PLANS TO WORK OUT QUANTITATIVELY THE LENGTH OF THE VARIOUS LIFE STAGES OF THE WEEVIL WERE INTERRUPTED BY THE SUSPENSION OF THE STUDY. CONSEQUENTLY COMPLETE DATA ARE AVAILABLE ONLY FOR THE PUPAL PERIOD. TO OBTAIN THIS INFORMATION, OBSERVATION BLOCKS (FIGURE 1) WERE CUT FROM INFESTED TREES, AND THE PREPUPAL LARVAE CONTAINED THEREIN WERE EXPOSED TO VIEW BY REMOVING THE BARK AND WOOD ABOVE THE PUPAL CHAMBER. THE LATTER WAS THEN COVERED WITH A SMALL PIECE OF TRANSPARENT SCOTCH TAPE TO PREVENT THE ESCAPE OF THE INSECT AND AT THE SAME TIME PERMIT OBSERVATION OF THE INSECT AT WILL. EXCEPT FOR EXPOSURE FOR DAILY EXAMINATION, THE OBSERVATION BLOCKS WERE KEPT DARK IN A COVERED BOX IN THE INSECTARY. THE FIRST TRANSFORMATION AMONG THE 63 INDIVIDUALS THAT SURVIVED THE OBSERVATION PERIOD, OCCURRED ON APRIL 22, WHILE THE LAST TOOK PLACE ON MAY 21. THE MEAN LENGTH OF THE PUPAL PERIOD WAS 26.24 ± 0.38 DAYS, WITH A MAXIMUM OF 35 AND A MINIMUM OF 20. THE LENGTH OF THE PERIOD BETWEEN TRANSFORMATION TO THE ADULT STAGE AND EMERGENCE OF THE MATURE WEEVIL AVERAGED 7 DAYS.

IN THIS LOT OF INSECTS 60.2 PERCENT WERE MALES AND 39.8 PERCENT FEMALES.

EMERGENCE

ALTHOUGH GENERAL RECORDS OF ADULT EMERGENCE WERE AVAILABLE FROM LAST SEASON'S NOTES, THE INFORMATION WAS NOT TAKEN IN SUCH A WAY AS TO PROVIDE A BASIS FOR THE CONSTRUCTION OF AN EMERGENCE CURVE. THIS YEAR, THROUGH THE MAINTENANCE OF PERIODIC COLLECTION RECORDS FROM 20 INDIVIDUALLY CAGED TREES TAKEN FROM BIG SPRINGS PRIOR TO TRANSFORMATION OF THE PUPAE, DATA WERE SECURED WHICH CAN BE PRESENTED IN THIS FORM (FIGURE 3). THIS FIGURE SHOWS THAT THE PEAK OF EMERGENCE OCCURS ABOUT A WEEK AFTER THE FIRST ADULTS COME OUT, BUT THAT MANY INDIVIDUALS DO NOT EMERGE UNTIL TWO OR THREE WEEKS LATER. IT IS QUITE PROBABLE THAT THE PEAK OF EMERGENCE FROM CAGED MATERIAL WILL NOT COINCIDE EXACTLY WITH NATURAL EMERGENCE, BUT REFERENCE TO THE FIELD NOTES REVEALS THAT THE WEEVILS WERE QUITE COMMON AT BIG SPRINGS DURING THE SAME PERIOD.



FIGURE 1. TRANSFORMATION OF IMMATURE STAGES OF THE WEEVIL WAS OBSERVED THROUGH CELLOPHANE WINDOWS COVERING THE PUPAL CHAMBERS IN SHORT SECTIONS OF INFESTED WOOD.

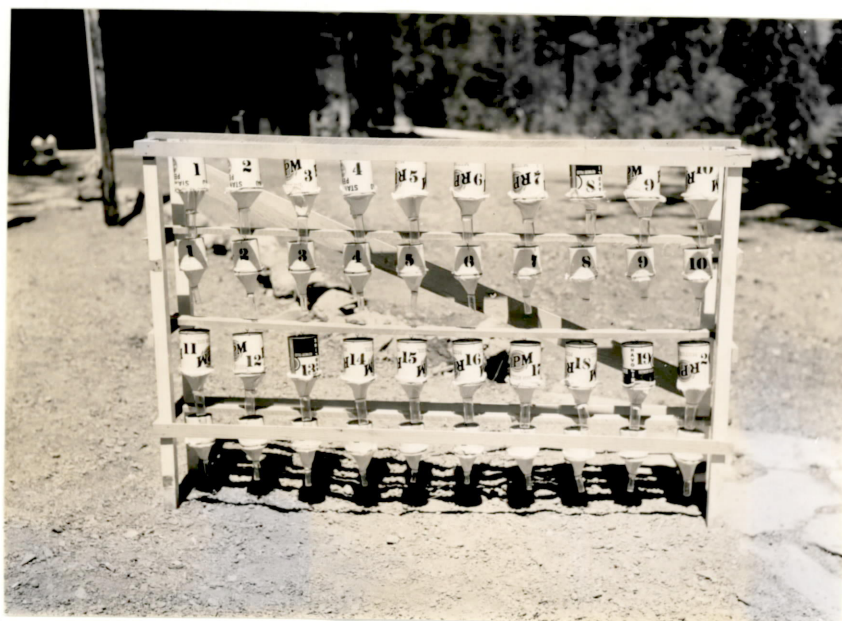


FIGURE 2. OIL-CAN CAGES WITH MUSLIN FUNNELS LEADING TO THE COLLECTING TUBES WERE USED IN REARING WEEVILS TO DETERMINE THE PROPORTION OF BROOD EMERGING FROM THE TOPS AND ROOTSTOCKS OF INFESTED TREES.

ONE PHASE OF EMERGENCE NOT PREVIOUSLY STUDIED IS THE PROPORTION OF THE BROOD OCCURRING IN THE TOPS OF INFESTED TREES AS COMPARED WITH THE NUMBER FOUND IN THE ROOTSTOCK. THIS MATTER IS OF INTEREST IN CONNECTION WITH THE APPLICATION OF ERADICATION CONTROL MEASURES, WHERE THE NECESSITY FOR PULLING UP THE TREES RATHER THAN CUTTING THEM OFF AT THE GROUND LEVEL HAS BEEN QUESTIONED. IN A SAMPLE OF 24 TREES SELECTED AT RANDOM IT WAS FOUND THAT LARVAL MINES EXTENDED INTO THE ROOTSTOCK IN 80 PERCENT OF THE CASES. THE AVERAGE DISTANCE BELOW THE GROUND LEVEL WAS 1 INCH, WITH A MAXIMUM OF 2 INCHES. TO DETERMINE WHETHER OR NOT THE LARVAE MINING IN THE ROOTSTOCK DEVELOP TO MATURITY, REARINGS WERE MADE FROM 20 INFESTED SEEDLINGS. THE TOPS AND ROOTSTOCKS WERE CAGED SEPARATELY IN EACH CASE (FIGURE 2). FROM THE RESULTS OF THIS WORK (TABLE 1) IT APPEARS THAT THERE IS A WIDE VARIATION IN THE TOP-ROOTSTOCK EMERGENCE RATIO, AS WOULD BE EXPECTED WHEN ONE CONSIDERS THE VARIATION IN THE VOLUME OF TOPS AS COMPARED TO THE ROOTSTOCKS. HOWEVER, CONSIDERING THE FACT THAT AN AVERAGE OF 1 WEEVIL EMERGES FROM THE ROOTSTOCK FOR EVERY 11 EMERGING FROM THE TOP (FIGURE 4), IT WOULD BE UNDESIRABLE TO LEAVE THE ROOTSTOCKS IN THE GROUND WHEN APPLYING MEASURES TO DESTROY INFESTED MATERIAL.

TABLE 1. EMERGENCE OF CYLINDROCOPTURUS ADULTS FROM TOPS AND ROOTS OF TRANSPLANTS

TREE SPECIES	TREE NUMBER	EMERGENCE		RATIO*	HEIGHT OF TREE	LENGTH OF ROOTSTOCK
		TOP	ROOTSTOCK			
PONDEROSA PINE	1	28	5	5.6	15 IN.	2 IN.
	2	73	8	9.1	16	2
	3	147	1	147.0	25	2
	4	84	7	12.0	21	1
	5	13	3	4.3	15	2
	6	434	9	48.2	25	2
	7	213	0		30	3
	8	99	23	4.3	16	2
	9	96	2	48.0	20	2
	10	49	6	8.2	11	3
TOTALS		1,236	64	19.3		
JEFFREY PINE	11	160	17	9.4	17	3
	12	132	24	5.5	21	3
	13	62	10	6.2	11	2
	14	173	17	10.2	27	2
	15	111	26	4.3	16	3
	16	112	7	16.0	18	3
	17	52	13	4.0	24	3
	18	149	17	8.8	17	3
	19	208	17	12.2	24	1
	20	29	0		12	2
TOTALS		1,188	148	8.0		
TOTALS - BOTH SPECIES		2,424	212	11.4		

* ROOTSTOCK EMERGENCE = 1.

FIGURE 3
RATE OF EMERGENCE OF ADULT WEEVILS
(BASED ON REARINGS FROM 20 TREES)

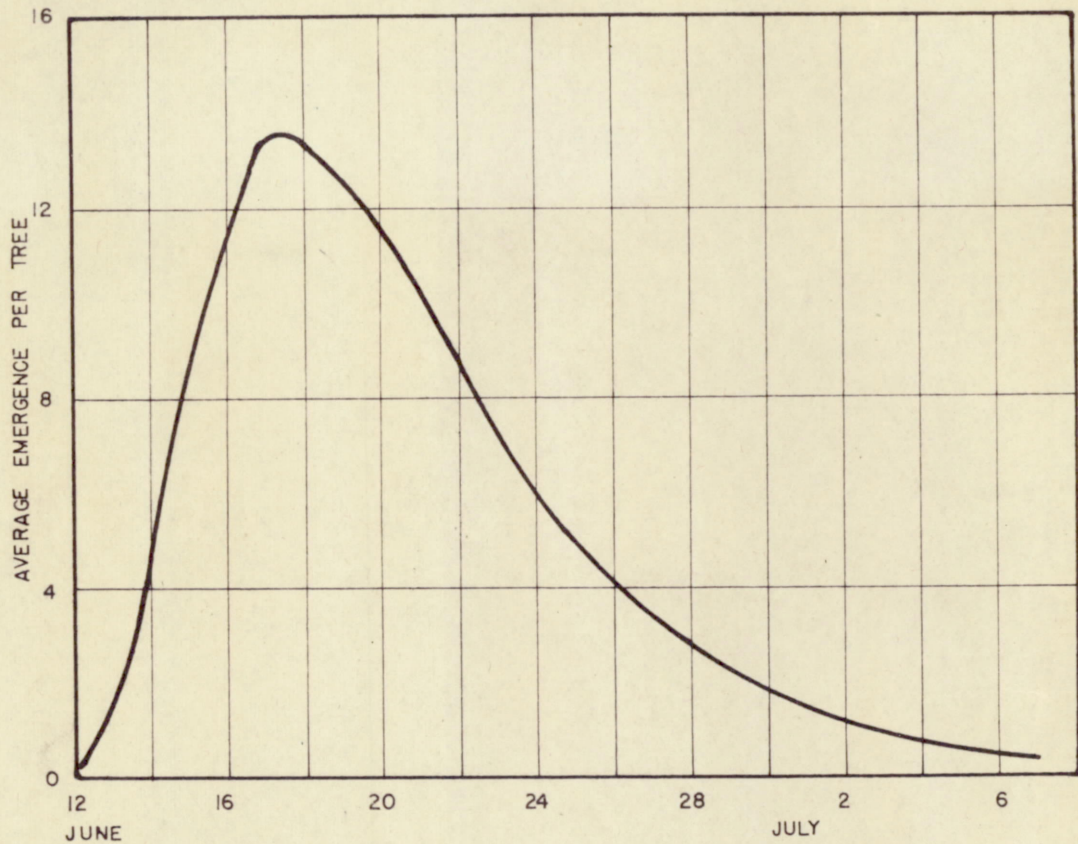
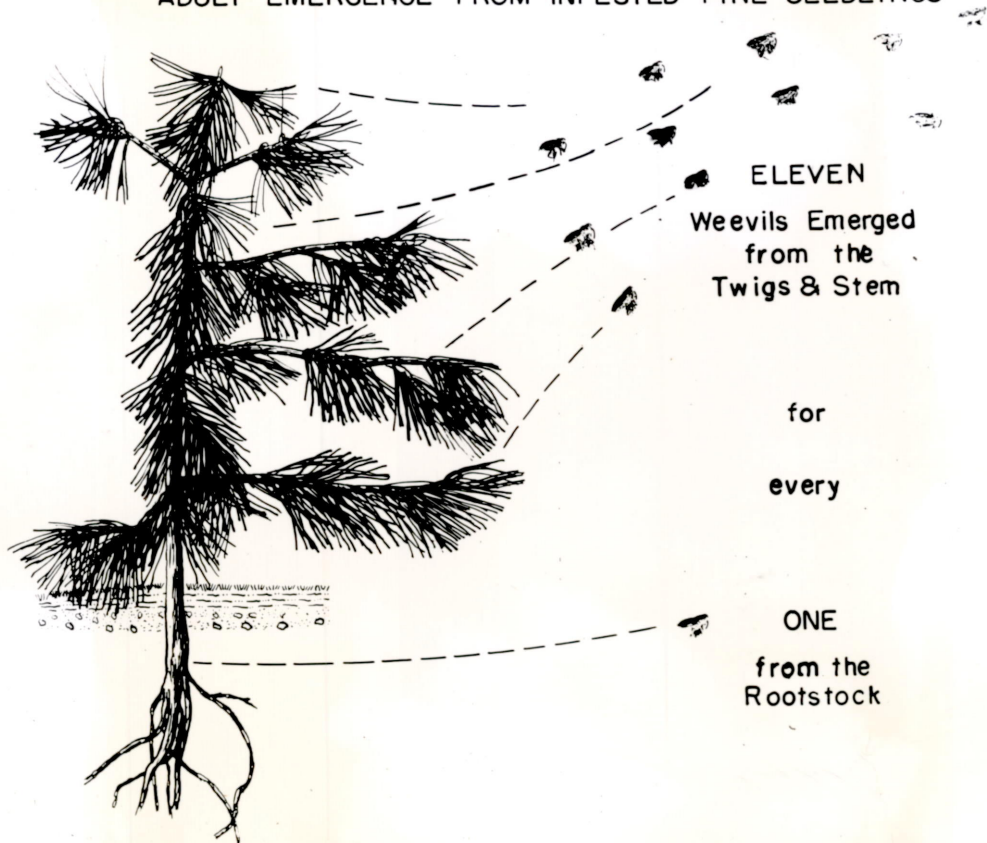


FIGURE 4

ADULT EMERGENCE FROM INFESTED PINE SEEDLINGS



OVERWINTERING STAGES

GENERALLY SPEAKING THE MAJORITY OF THE OVERWINTERING BROOD CONSISTS OF MATURE LARVAE. THE DISCOVERY OF AN OCCASIONAL CALLOW ADULT IN THE 1939 BROOD LATE LAST FALL WAS CONSIDERED AT THE TIME TO BE AN ABERRATION IN HABIT, DUE PERHAPS TO THE INFLUENCE OF SOME UNUSUAL ENVIRONMENTAL FACTOR. THIS FALL, HOWEVER, CALLOW ADULTS AMONG A BROOD COMPRISED PREDOMINANTLY OF LARVAE WERE AGAIN FOUND TO BE OVERWINTERING, INDICATING THAT THE VARIATION MAY BE A FAIRLY COMMON OCCURRENCE.

FORCED ATTACK STUDIES

BECAUSE OF THE INADEQUACY OF LAST YEAR'S EFFORTS TO TEST FULLY THE ABILITY OF THE WEEVIL TO KILL NATIVE REPRODUCTION, ADDITIONAL TESTS WERE MADE THIS SEASON. BEFORE THE 1940 BROOD EMERGED, INFESTED MATERIAL WAS COLLECTED FROM THE BIG SPRINGS BRUSHFIELD AND CAGED AROUND A SERIES OF YOUNG, NATURALLY ESTABLISHED SEEDLINGS NEAR HAT CREEK. TEN INDIVIDUALS OF EACH OF THE FOLLOWING TREE SPECIES WERE USED IN THIS EXPERIMENT: PONDEROSA PINE, SUGAR PINE, WHITE FIR, AND DOUGLAS FIR. AS BEFORE, THE TWO-LEG, SACK-TYPE MUSLIN CAGES WERE EMPLOYED TO CONFINE THE EMERGING WEEVILS TO THE TREES. THE RESULTS OF THE FORCED ATTACK EXPERIMENTS FOR BOTH SEASONS ARE GIVEN IN TABLE 2.

TABLE 2. SUMMARY OF RESULTS OF FORCED ATTACK TESTS

TREE SPECIES	INFESTED MAY 1939			INFESTED MAY 1940			TOTAL		
	No. TREES		MORTALITY	No. TREES		MORTALITY	No. TREES		MORTALITY
	INFESTED	No.		INFESTED	No.		INFESTED	No.	
PONDEROSA PINE	10	5	50	10	5	50	20	10	50
JEFFREY PINE	7	5	71	NONE	-	-	7	5	71
SUGAR PINE	1	0	0	10	7	70	11	7	63
DOUGLAS FIR	2	1	50	10	8	80	12	9	75
WHITE FIR	NONE	-	-	10	0	0	10	0	0

IT WILL BE SEEN FROM THESE DATA THAT THE MORTALITY OF DOUGLAS FIR WAS SLIGHTLY HIGHER THAN THAT OF JEFFREY PINE, AND CONSIDERABLY HIGHER THAN THAT OF PONDEROSA PINE. THAT THESE RESULTS DO NOT BEAR OUT PREVIOUS STATEMENTS IS DUE IN PART TO THE INADEQUACY OF EARLIER TESTS MADE WITH FIR. IT SHOULD BE NOTED, HOWEVER, THAT DESPITE THE FACT THAT WEEVILS CONFINED ON CAGED DOUGLAS FIR SEEDLINGS WERE ABLE TO CAUSE DEATH, NO EVIDENCE HAS YET BEEN SECURED THAT THE SPECIES C. EATONI COMMONLY BREEDS IN THIS HOST, OR THAT IT WILL DO SO UNDER FORCED REARING. IN THE ONE FIR TREE KILLED LAST SEASON, GALLERIES OF THE IMMATURE LARVAE WERE FOUND, BUT NO INDIVIDUALS DEVELOPED TO THE ADULT STAGE. IT REMAINS TO BE SEEN WHETHER OR NOT THE INSECT WILL BREED SUCCESSFULLY IN THIS OR OTHER SPECIES OF TREES NOT APPARENTLY ITS CUSTOMARY HOST.

ASSOCIATED ORGANISMS

PARASITES

NINE SPECIES OF PARASITES OF THE WEEVIL, IDENTIFIED BY SPECIALISTS, HAVE BEEN RECOVERED IN THE TWO SEASONS' REARINGS. FROM THE SCANTY INFORMATION AT HAND IT IS BELIEVED THAT THE SPECIES TELENOMUS NEAR CHRYSOPE ASHM. IS THE FIRST RECORDED EGG PARASITE OF THE WEEVIL. ITS ABUNDANCE IS NOT KNOWN. REARINGS OF PARASITIZED WEEVIL LARVAE, REMOVED FROM THE PUPAL CHAMBERS IN THE WOOD, INDICATE THAT THE CHALCID RHOPALICUS PULCHRIENNIS (CWF.D.) IS THE MOST IMPORTANT PARASITE OF THE LARVAL STAGE. AMONG 65 INDIVIDUALS EMERGING FROM THE HOST LARVAE, 61 BELONGED TO THIS SPECIES AND THE REMAINING 4 WERE SPECIMENS OF EURYTOMA TOMICI ASHM. IN NO CASE WAS MORE THAN ONE OF THESE PARASITES RECOVERED FROM A SINGLE WEEVIL LARVA. NO OTHER PARASITES WERE REARED FROM SPECIFIC STAGES OF THE HOSE; THEREFORE JUST HOW TETRASTICHUS SP. NEAR CLISIOCAMPAE GIR. AND ZAGELLA SP. AFFECT THE HOST IS NOT KNOWN.

WHILE NO INFORMATION IS AVAILABLE ON THE ABUNDANCE OF PARASITES IN RELATION TO THE HOST UNDER FIELD CONDITIONS, IT WAS FOUND THAT THE RATIO WAS 1:23 FOR THE EMERGENCE FROM THE TOP-ROOTSTOCK CAGES PREVIOUSLY MENTIONED. IN THIS CASE THE RELATIVE IMPORTANCE OF THE DIFFERENT SPECIES FROM THE STANDPOINT OF NUMBERS IS INDICATED IN THE FOLLOWING TABULATION:

<u>SPECIES</u>	<u>EMERGENCE</u>
<u>RHOPALICUS PULCHRIENNIS</u>	93
<u>EURYTOMA TOMICI</u>	7
<u>TELENOMUS</u> SP.	1
<u>TETRASTICHUS</u> SP.	1
OTHER SPECIES	14
TOTAL	116
TOTAL NUMBER OF WEEVILS	2,636

CONTROL INVESTIGATIONS

POPULATION REDUCTION

BECAUSE OF THE URGENCY FOR DOING SOMETHING TO CONTROL THE WEEVIL INFESTATION IN THE BIG SPRINGS PLANTATION, RECOMMENDATIONS WERE MADE TO THE FOREST SERVICE LAST SPRING THAT THE INFESTED TREES BE DESTROYED BEFORE THE 1940 BROOD EMERGED. ACCORDINGLY, DURING THE MIDDLE OF APRIL, CONTROL OPERATIONS WERE PERFORMED BY A CREW FROM THE HAT CREEK CREEK CCC CAMP UNDER THE SUPERVISION OF THE WRITER, AS ALREADY REPORTED (EATON, 1940B). THE JOB REQUIRED 63 MAN-DAYS OF LABOR, EXCLUSIVE OF SUPERVISION. IF THE COST OF CCC LABOR IS FIGURED AT \$3.00 PER DAY, THE TOTAL COST OF THE CONTROL WORK WAS THEN \$189.00.

A MEASUREMENT OF THE EFFICACY OF THIS OPERATION IS RATHER DIFFICULT TO OBTAIN, SINCE NO CHECK AREA OF COMPARABLE CHARACTER WAS AVAILABLE, NOR WAS IT CONSIDERED ADVISABLE AT THE TIME TO LEAVE A PART OF THE BIG SPRINGS PLANTINGS FOR THIS PURPOSE. FROM A SURVEY MADE IN NOVEMBER, HOWEVER, IT WAS FOUND THAT THE LOSSES CONTINUED IN 1940 IN SPITE OF THE ERADICATION WORK. THIS STATEMENT IS BASED ON THE RESULTS OF A ONE PERCENT SAMPLING OF THE 173 MILES (APPROXIMATELY) OF PLANTED ROWS IN THE BRUSHFIELD. THE METHOD OF MAKING THIS SURVEY WAS TO COUNT GREEN AND DEAD TREES ON 1 CHAIN IN EVERY 10 CHAINS IN EVERY 10TH ROW (FIGURE 5). A SUMMARY OF THE RESULTS OF THIS WORK IS GIVEN IN TABLE 3.

TABLE 3. ESTIMATE OF CYLINDROCOPTURUS DAMAGE DURING 1940
BIG SPRINGS PLANTATION, LASSEN NATIONAL FOREST

YEAR OF PLANTING	NO. OF SAMPLES (1 CHAIN EACH)	NO. OF TREES PER CHAIN OF ROW			MORTALITY	
		TOTAL	LIVING	DEAD	PERCENT	ST.ERROR
PONDEROSA PINE						
1932-33	2	3.5	3.0	0.5	14.3	*
1934	6	3.7	2.7	1.0	27.0	+15.99
1935	8	4.0	2.9	1.1	27.5	+ 7.51
1936	19	4.7	4.2	0.5	10.6	+ 6.14
1937	43	6.2	5.4	0.8	12.9	+ 4.49
ALL AGES	78	5.3	4.6	0.7	13.2	+ 2.90
JEFFREY PINE						
1932-33	2	2.5	2.0	0.5	20.0	*
1934	3	1.7	1.0	0.7	41.2	*
1937	55	5.3	5.1	0.2	3.8	+ 1.05
ALL AGES	60	5.1	4.8	0.3	5.9	+ 1.49
BOTH SPECIES						
ALL AGES	138	5.2	4.7	0.5	9.6	+ 1.82

* INSUFFICIENT SAMPLES TAKEN FOR THESE ESTIMATES TO BE SIGNIFICANT.

THESE DATA SHOW THAT FOR THE ENTIRE PLANTATION THE AVERAGE LOSS FOR 1940 WAS 9.6 PERCENT, OR SLIGHTLY LESS THAN ONE TREE IN EVERY TEN LIVING LAST SPRING AFTER THE ERADICATION WORK HAD BEEN COMPLETED (FIGURE 6). OBVIOUSLY IF THE MORTALITY CONTINUES AT THIS RATE THERE WILL BE LITTLE LEFT OF THE PLANTINGS IN TEN YEARS. COMPARING LOSS BY SPECIES IT IS APPARENT THAT PONDEROSA PINE SUFFERED TWICE THE MORTALITY OF JEFFREY PINE. IT MAY BE WELL TO RECALL THAT LAST YEAR'S SURVEYS SHOWED A MORTALITY BETWEEN 70 AND 90 PERCENT FOR THE VERY OLDEST PLANTINGS, THUS THERE IS NOT MUCH LEFT IN THESE AREAS FOR THE WEEVILS TO ATTACK. JUDGING FROM THE DISTRIBUTION OF THE SAMPLE PLOTS IN WHICH ONE OR MORE INFESTED TREES WERE FOUND (SEE FIGURE 5), THE INFESTATION IS SPREAD PRETTY WELL OVER THE ENTIRE AREA.

THE WRITER IS OF THE OPINION THAT THE INEFFECTIVENESS OF THE ERADICATION WORK IN THIS INSTANCE IS DUE NOT TO THE OVERLOOKING OF INFESTED TREES IN THE BRUSHFIELD ITSELF, BUT RATHER TO THE PRESENCE OF AN ABUNDANT SUPPLY OF WEEVILS IN THE SURROUNDING FOREST. THE OBVIOUS DIFFICULTIES OF ATTEMPTING TO DESTROY THIS SOURCE OF INFESTATION RAISE THE QUESTION OF WHETHER OR NOT PULLING AND BURNING WILL EVER BE SATISFACTORY IN CHECKING THE DAMAGE. THE ALTERNATIVE TO THIS METHOD OF CONTROL IS TO ATTEMPT TO COMBAT THE INSECT WITH CHEMICALS.

CONCENTRATED SPRAYS

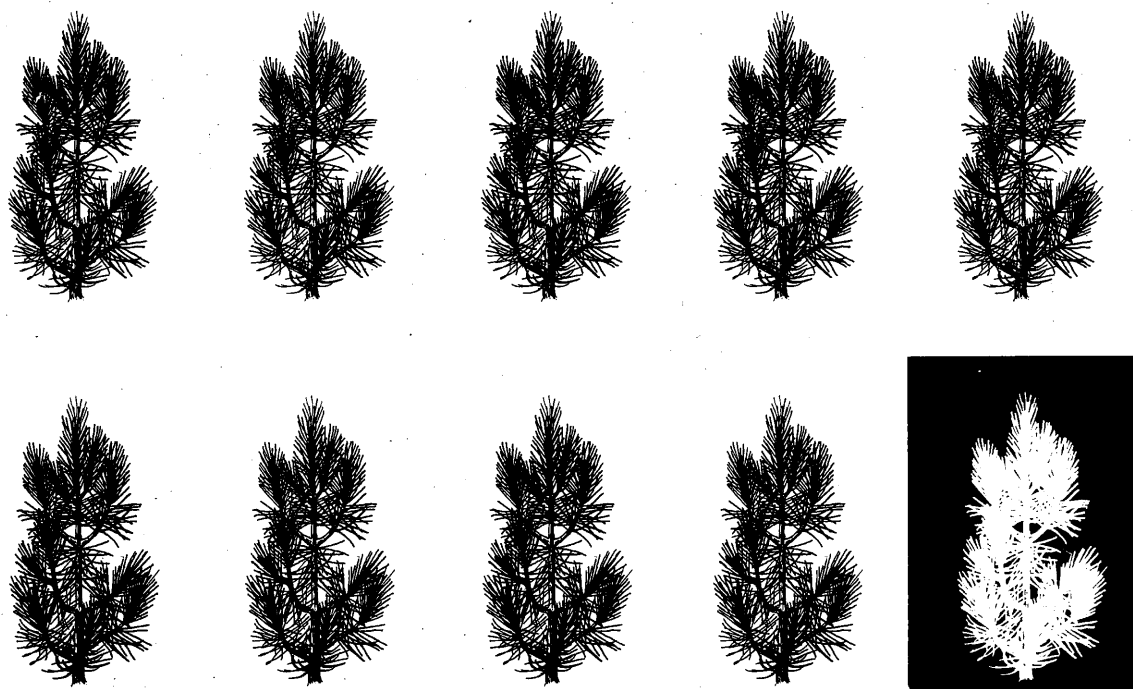
IN NORTHEASTERN UNITED STATES EXPERIMENTAL TESTS WITH CONCENTRATED SPRAYS FOR THE CONTROL OF VARIOUS FOREST INSECTS HAVE BEEN UNDER WAY FOR THE PAST DECADE (POTTS, 1940). ACCORDING TO UNPUBLISHED REPORTS BY MR. POTTS, CONCENTRATED SPRAYS HAVE BEEN FOUND EFFECTIVE IN PREVENTING DAMAGE TO EASTERN WHITE PINE BY THE WEEVIL PISSODES STROBI PECK. THE SUCCESS OF THIS WORK SUGGESTED THE POSSIBILITY THAT SIMILAR MATERIALS MIGHT BE OF VALUE FOR THE CONTROL OF THE CYLINDROCOPTURUS WEEVIL IN PONDEROSA AND JEFFREY PINE PLANTATIONS. ACCORDINGLY SMALL SCALE LABORATORY AND FIELD TESTS WERE SET UP THIS SPRING TO EVALUATE THIS METHOD.

MATERIALS AND METHODS

IN VIEW OF THE WORK ALREADY COMPLETED IN THE EAST, THE MATERIALS TRIED IN THE PRESENT INSTANCE WERE LIMITED TO LEAD ARSENATE AND CRYOLITE, BOTH OF WHICH WERE USED IN CONCENTRATED FORM. WHILE THE TESTING OF CONVENTIONAL SPRAY CONCENTRATIONS WOULD ALSO HAVE BEEN DESIRABLE FOR COMPARISON WITH THE LATTER, THE MATERIALS AND TIME WERE NOT AVAILABLE FOR THE ADDITIONAL WORK INVOLVED.

WITH AN INSECTICIDE IN POWDER FORM, CONCENTRATED MIXTURES USUALLY CONTAIN (IN ADDITION TO A WATER OR AN OIL CARRIER) ONE OR MORE OF THE FOLLOWING MATERIALS: A WETTING OR SPREADING AGENT, AN ADHESIVE OIL, AND OCCASIONALLY INGREDIENTS SUCH AS GLYCERINE OR DIETHYLENE GLYCOL TO PREVENT TOO RAPID DRYING. THE TWO TYPES OF CONCENTRATED SPRAYS USED BY THE WRITER CONTAINED THE FOLLOWING INGREDIENTS:

SEEDLING MORTALITY AT BIG SPRINGS PLANTATION



Weevils killed ONE (9.6%) out of every TEN pine transplants in the summer of 1940

FIGURE 6

	FORMULA 1		FORMULA 3	
	MATERIAL	PARTS BY WEIGHT	MATERIAL	PARTS BY WEIGHT
INSECTICIDE	ACID LEAD ARSENATE	1	SYNTHETIC CRYOLITE	1
LIGHT OIL	SUMMER VAPOROL	0.25	(NONE)	
WETTING AGENT	VATSOL O. S.	0.03	VATSOL O. S.	0.01
CARRIER	WATER	1.0	WATER	2.01

THE SAME INSECTICIDES WERE ALSO TRIED ON A SMALL SCALE WITH A LIGHT OIL AS A CARRIER, BUT SUCH SEVERE BURNING OF THE NEEDLES RESULTED THAT THE MIXTURES ARE CONSIDERED TO BE OF LITTLE VALUE.

SINCE IT IS NECESSARY THAT CONCENTRATED SPRAYS BE FINELY ATOMIZED IN ORDER TO OBTAIN THE BEST COVERAGE AND PREVENT EXCESS DEPOSIT, A SMALL QUART-SIZED PAINT SPRAY GUN (FIGURE 7) WAS USED FOR APPLYING THE MATERIAL. COMPRESSED AIR WAS SUPPLIED BY A PORTABLE GASOLINE-POWERED COMPRESSOR MOUNTED ON A WHEELBARROW CHASSIS (FIGURE 8). THIS RIG WAS ORIGINALLY DEVELOPED FOR SPRAYING PAINT NUMBERS ON TREES IN FOREST SAMPLE PLOTS, BUT IT WAS FOUND TO BE ADMIRABLY SUITED FOR THE EXPERIMENTAL WORK UNDER DISCUSSION. OBVIOUSLY, MORE SUBSTANTIAL APPARATUS WITH GREATER CAPACITY FOR SPRAY MATERIALS WOULD BE NECESSARY FOR CARRYING OUT A LARGE SCALE SPRAY PROGRAM.

DESCRIPTION OF TESTS MADE

THE SPRAYS WERE TESTED UNDER BOTH LABORATORY AND FIELD CONDITIONS, USING GREEN TREES IN POTS IN THE FORMER CASE (FIGURE 9) AND LIVING TRANSPLANTS ALREADY ESTABLISHED IN THE BIG SPRINGS BRUSHFIELD IN THE LATTER (FIGURE 10). THE POTTED TREES WERE KEPT IN IRRIGATION TRENCHES, SINCE THEY COULD NOT BE WATERED FROM THE TOP AFTER BEING CAGED. THE SPRAYS WERE APPLIED EARLY IN JUNE, USING APPROXIMATELY ONE-TENTH OF A PINT PER TREE. IN THE LABORATORY TESTS A SERIES OF 10 TREES WERE TREATED WITH EACH CHEMICAL, OF WHICH 5 WERE LATER CAGED (FIGURE 11) AND EXPOSED TO ATTACK BY SEVERAL HUNDRED WEEVILS CONFINED ON THEM. THE REMAINING 5 TREATED TREES WERE NOT SUBJECTED TO WEEVIL ATTACK, BUT WERE LEFT UNCAGED TO TEST THE EFFECTS OF THE CHEMICAL ALONE ON THE FOLIAGE. THE CHECK SERIES CONSISTED OF 5 UNSPRAYED TREES ON WHICH WEEVILS WERE CONFINED. IN THE FIELD EXPERIMENTS 10 INSTEAD OF 5 SEEDLINGS SERVED AS THE UNIT FOR EACH TEST, AND SLIGHTLY DIFFERENT CAGES WERE USED TO CONFINE THE WEEVILS TO THE TREES (FIGURE 12). THE RESULTS OF THESE TESTS ARE SUMMARIZED IN TABLE 4.



FIGURE 7. A CONCENTRATED SPRAYS TO PREVENT WEEVIL ATTACK WERE TESTED ON PINE TRANSPLANTS GROWING IN THE BIG SPRINGS BRUSHFIELD. A, CLOSE-UP OF PAINT SPRAY GUN BEING USED TO APPLY LEAD ARSENATE. B, WHEELBARROW TYPE GASOLINE-POWERED COMPRESSOR WHICH FURNISHED THE AIR SUPPLY.



FIGURE 8. THE PAINT SPRAY RIG, ORIGINALLY DEVELOPED FOR NUMBERING TREES ON FOREST SAMPLE PLOTS, CAN BE READILY TRANSPORTED IN THE BACK OF A PICKUP TRUCK.



FIGURE 9. CONCENTRATED SPRAYS WERE TESTED UNDER LABORATORY CONDITIONS WITH POTTED TREES, SHOWN HERE IN THE IRRIGATION TRENCHES BY MEANS OF WHICH THE SEEDLINGS WERE WATERED.



FIGURE 10. THE SPRAYS WERE ALSO TESTED UNDER CONDITIONS FOUND IN THE FIELD WITH PINE SEEDLINGS GROWING IN THE BIG SPRINGS AREA.



FIGURE 11. WOODEN FRAMED CAGES COVERED WITH MUSLIN AND FACED ON ONE SIDE WITH CELLULOID, WERE USED TO CONFINED WEEVILS ON POTTED SEEDLINGS IN SPRAY TESTS MADE AT THE LABORATORY.



FIGURE 12. TWO-LEG A SACK-TYPE MUSLIN CAGES, DEVELOPED LAST YEAR, WERE USED TO CONFINED WEEVILS ON TEST TREES AT BIG SPRINGS. A, THIS PICTURE SHOWS THE METHOD OF INSTALLING THE CAGE. B, A ROW OF COMPLETED CAGES.

TABLE 4. SUMMARY OF TESTS WITH CONCENTRATED SPRAYS

SPRAY	NO. OF TREES	NO. WEEVILS CAGED ON EACH TREE	TREE MORTALITY		REMARKS
			NUMBER	PERCENT	
<u>TESTS WITH POTTED TREES</u>					
LEAD ARSENATE	5	400	0	0	LEADER KILLED IN ONE CASE. 11/6/40.
	5*	0	0	0	
SYNTHETIC CRYOLITE	5	300	0	0	TIP OF LEADER KILLED IN ONE CASE. 11/6/40.
	5*	0	0	0	
CHECK	5	300	5	100	ALL TREES WITH RED FOLIAGE. 11/6/40.
<u>TESTS WITH TREES GROWING IN THE BIG SPRINGS BRUSHFIELD</u>					
LEAD ARSENATE	10	300	0	0	ALL TREES GREEN, LIVING AND HEALTHY WITH NO INDICATIONS OF INJURY. 11/6/40.
	10*	0	0	0	
SYNTHETIC CRYOLITE	10	250	0	0	
	10*	0	0	0	
CHECK	10	200	10	100	ALL TREES WITH RED FOLIAGE. 11/6/40.

* THIS SERIES SET UP TO TEST THE EFFECTS OF THE CHEMICAL ALONE ON THE FOLIAGE.

RESULTS AND DISCUSSION

THE RESULTS OF THESE EXPERIMENTS ARE CLEARCUT, AND IT IS APPARENT THAT UNDER THE CONDITIONS OF THE TEST, CONCENTRATED SPRAYS OF EITHER LEAD ARSENATE OR CRYOLITE ARE VERY EFFECTIVE IN PREVENTING DAMAGE TO PINE REPRODUCTION BY THE WEEVIL. UNSPRAYED CHECK TREES, WHEN INFESTED ARTIFICIALLY, WERE KILLED IN EVERY CASE. A DETAILED STUDY OF SAMPLES OF FOLIAGE FROM EACH OF THE TREES USED IN THE INSECTARY SPRAY TESTS SHOWED THAT THERE WAS A MARKED DIFFERENCE IN THE NUMBER OF FEEDING PUNCTURES ON UNSPRAYED AS CONTRASTED WITH SPRAYED NEEDLES. ON THE BASIS OF COUNTS AND MEASUREMENTS OF 50 NEEDLES FROM EACH LOT, THE SPRAYED TREES HAD 0.1 TO 0.2 OF A PUNCTURE PER LINEAR INCH, AS COMPARED WITH OVER 14 PUNCTURES PER LINEAR INCH FOR THE UNSPRAYED TREES.

NO DELETERIOUS EFFECTS ATTRIBUTABLE TO THE CHEMICAL WERE EVIDENT ON ANY OF THE TREATED TREES FIVE MONTHS AFTER THE SPRAY WAS APPLIED, IN SPITE OF THE FACT THAT HEAVY DEPOSITS OF THE INSECTICIDE WERE SECURED IN EVERY CASE. PINE FOLIAGE APPEARS TO BE QUITE RESISTANT TO BOTH LEAD ARSENATE AND CRYOLITE. THESE TWO CHEMICALS SEEM TO WEATHER FAIRLY WELL, AND IT IS DOUBTFUL IF MORE THAN ONE SPRAY APPLICATION WOULD BE NECESSARY UNDER THE CLIMATIC CONDITIONS OF THE BIG SPRINGS AREA.

THE SUCCESS OF THIS EXPERIMENTAL WORK RAISES THE QUESTION OF WHETHER OR NOT CHEMICAL CONTROL COULD BE APPLIED ON A LARGE SCALE BASIS, SUCH AS WOULD BE NECESSARY AT BIG SPRINGS. THE ONLY WAY IN WHICH THIS QUESTION CAN BE SATISFACTORILY ANSWERED IS BY TRIAL. THE FEASIBILITY OF THE UNDERTAKING IS DEPENDENT ON TWO THINGS: (1) THE DEVELOPMENT OF PRACTICAL EQUIPMENT FOR RAPID APPLICATION OF THE SPRAY; AND (2) COSTS. THROUGH LACK OF EXPERIENCE NO ADEQUATE COST ESTIMATE FOR SUCH A PROJECT CAN BE MADE; HOWEVER, AN ESTIMATE OF THE COST OF THE INSECTICIDE CAN BE DERIVED FROM THE DATA FROM THE EXPERIMENTAL TESTS. IN THE LATTER ONE PINT OF CONCENTRATED SPRAY MIXTURE WAS SUFFICIENT TO SPRAY 10 TREES. SINCE THE MIXTURE CONTAINS APPROXIMATELY 10 PERCENT LEAD ARSENATE BY WEIGHT, ONE POUND OF THE INSECTICIDE WOULD BE SUFFICIENT FOR 100 TREES. IT IS ESTIMATED (FROM DATA IN TABLE 3) THAT THERE ARE 173 MILES OF PLANTED ROW IN THE BRUSHFIELD, HAVING AN AVERAGE OF 4.7 LIVING TREES PER CHAIN, OR (4.7 x 80 CHAINS x 173 MILES) 65,048 TREES. APPROXIMATELY 650 POUNDS OF LEAD ARSENATE WOULD THEREFORE BE NECESSARY TO SPRAY THIS NUMBER OF TREES. AT A COST OF \$0.11 PER POUND THIS WOULD MEAN AN OUTLAY OF \$71.50 FOR THE CHEMICAL. THE OTHER INGREDIENTS OF THE SPRAY COULD BE PURCHASED FOR A FEW DOLLARS SINCE RELATIVELY SMALL AMOUNTS WOULD BE NEEDED.

THE COST OF LABOR WOULD BE THE ONLY OTHER MAJOR ITEM, AND IT IS LARGELY DEPENDENT ON THE TYPE OF EQUIPMENT USED. IT HAS ALREADY BEEN POINTED OUT THAT THE SPRAY RIG EMPLOYED FOR THIS SEASON'S EXPERIMENTAL WORK WOULD BE TOO LIGHT FOR USE IN A REGULAR SPRAY CONTROL PROGRAM. POWER DRIVEN EQUIPMENT WHICH COULD BE RUN ALONGSIDE OR OVER THE TREES WOULD PROBABLY BE NECESSARY. THE SPRAY COULD BE APPLIED ANY TIME AFTER THE SPRING RAINS HAVE CEASED, BUT THE PROGRAM WOULD HAVE TO BE COMPLETED BY THE FIRST OF JUNE WHEN THE WEEVILS BEGIN TO EMERGE. A PERIOD OF TWO OR THREE WEEKS WOULD THUS BE AVAILABLE FOR THE WORK.

WEEVIL DAMAGE IN OTHER AREAS

ALTHOUGH THE SURVEY OF EXISTING PLANTATIONS IN NORTHERN CALIFORNIA, PROPOSED FOR THE PAST TWO SEASONS, WAS NOT MADE THIS YEAR, A FEW MISCELLANEOUS NOTES WERE SECURED WHICH SHOULD BE ADDED TO THE RECORD TO SUPPLEMENT OUR KNOWLEDGE OF THE DISTRIBUTION OF THE INSECT. WEEVILED JEFFREY AND PONDEROSA PINE SEEDLINGS IN NATURAL REPRODUCTION WERE FOUND IN MANY PARTS OF THE BLACK'S MOUNTAIN EXPERIMENTAL FOREST THIS SUMMER, WITH INDICATIONS THAT PREVIOUS INJURY HAS OCCURRED. ADULTS WERE REARED FROM INFESTED SEEDLINGS COLLECTED NEAR HACKAMORE ON THE MODOC NATIONAL

FOREST BY J. W. JOHNSON. FOLLOWING UP REPORTS OF DAMAGE IN EXPERIMENTAL PINE PLANTINGS ON BLUE MOUNTAIN, MODOC NATIONAL FOREST, K. A. SALMAN FOUND THE INFESTED MATERIAL SIMILAR TO THAT AT BIG SPRINGS AND ATTRIBUTED THE LOSSES TO THE WEEVIL. MINOR DAMAGE IN THE BURNEY SPRING AREA WAS AGAIN NOTED THIS FALL BY R. C. HALL.

SUMMARY

1. INVESTIGATIONS ON THE BIOLOGY AND CONTROL OF THE WEEVIL CAUSING DAMAGE TO PONDEROSA AND JEFFREY PINE TRANSPLANTS AT BIG SPRINGS BRUSHFIELD, LASSEN NATIONAL FOREST, WERE CONTINUED DURING THE SPRING OF 1940 AND TERMINATED ON JULY 1.
2. THE WEEVIL, FORMERLY CONSIDERED A VARIETY OF THE CYLINDROCOPTURUS LONGULUS COMPLEX, WAS DESCRIBED THIS YEAR UNDER THE NAME CYLINDROCOPTURUS EATONI BUCHANAN AS ONE OF THREE NEW SPECIES COMMONLY FOUND IN WESTERN FORESTS.
3. A RECHECK OF THE HABITS OF THE INSECT HAS SHOWN THAT THE MAIN FEATURES OF THE LIFE HISTORY ARE ESSENTIALLY CORRECT AS REPORTED LAST SEASON.
4. IT WAS FOUND THAT THE LARVAE USUALLY MINE IN THE ROOTSTOCK TO A DEPTH OF 1 INCH BELOW THE GROUND SURFACE, AND THAT SINCE ONE WEEVIL EMERGES FROM THE ROOTSTOCK FOR EVERY 11 EMERGING FROM THE TOP, THE TREES SHOULD BE PULLED UP RATHER THAN CUT OFF WHEN MEASURES ARE BEING TAKEN TO DESTROY INFESTED STOCK.
5. FORCED ATTACK STUDIES, REPEATED THIS YEAR, SHOWED THAT THE WEEVIL WILL KILL DOUGLAS FIR AS WELL AS PONDEROSA, JEFFREY AND SUGAR PINES, BUT THERE IS NO EVIDENCE THAT THE SPECIES WILL BREED IN THE FIR OR THE SUGAR PINE.
6. NINE SPECIES OF PARASITES AND ONE PREDATOR HAVE BEEN RECOVERED FROM WEEVIL INFESTED MATERIAL, OF WHICH THE MOST COMMON IS RHOPALICUS PULCHRI-PENNIS, A PARASITE OF THE LARVAL STAGE. REARINGS INDICATE THAT NEITHER THE PARASITES NOR THE PREDATOR ARE ABUNDANT ENOUGH TO KEEP THE WEEVIL POPULATION UNDER CONTROL AT BIG SPRINGS.
7. FURTHER TESTS BY THE OFFICE OF FOREST PATHOLOGY INDICATE THAT THE BLUESTAIN FUNGUS HORMISCIMUM GELATINOSUM, USUALLY ASSOCIATED WITH CYLINDROCOPTURUS, IS NONPATHOGENIC; THEREFORE THE WEEVIL MUST BE CONSIDERED THE MAJOR AGENCY RESPONSIBLE FOR THE INJURY.
8. LATE FALL SURVEYS AT BIG SPRINGS SHOWED THAT IN SPITE OF THE ERADICATION OF INFESTED MATERIAL BY THE HAT CREEK CCC CAMP EARLY LAST SPRING, AN AVERAGE OF ONE TREE OUT OF EVERY TEN IN THE ENTIRE PLANTATION WAS KILLED BY WEEVILS IN THE SUMMER OF 1940. IT IS CONCLUDED THAT THIS METHOD OF PREVENTING DAMAGE IS INEFFECTIVE.

9. EXPERIMENTAL TESTS CONDUCTED UNDER BOTH LABORATORY AND FIELD CONDITIONS SHOW THAT CONCENTRATED SPRAYS WILL EFFECTIVELY PREVENT INJURY TO TREES EXPOSED TO ATTACK BY THE WEEVILS. THE FEASIBILITY OF THIS METHOD FOR LARGE SCALE CONTROL IS DISCUSSED.

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